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Report to the Chairman, Environment, Energy, and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives

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HAZARDOUS WASTE

Controls Over Injection Well Disposal Operations Protect Drinking Water

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August 28, 1987

The Honorable Mike Synar
Chairman, Environment, Energy,
and Natural Resources Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

As requested in your March 3, 1986, letter, and in subsequent discussions with your office, we have reviewed the Environmental Protection Agency's (EPA) controls for hazardous waste underground injection well operations. Under the Safe Drinking Water Act, EPA established these controls to protect underground sources of drinking water from improper injection of hazardous waste.

As arranged with your office, unless you publicly announce its contents earlier, we will make this report available to other interested parties 30 days after the date of this letter. At that time, we will also send copies to other appropriate congressional committees; the Administrator, EPA; and the Director, Office of Management and Budget.

This work was performed under the direction of Hugh J. Wessinger, Senior Associate Director. Other major contributors are listed in appendix I.

Sincerely yours,

J. Dexter Peach

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

Half of the water that Americans rely on for drinking comes from underground sources. About 59 percent of all hazardous waste currently disposed of in the United States is handled by underground injection wells. Without adequate safeguards over the disposal of this waste, underground sources of drinking water can become contaminated. Effective oversight of the operation of these wells by the Environmental Protection Agency (EPA) through its Underground Injection Control Program is essential to assuring that injected waste does not contaminate sources of drinking water.

At the request of the Chairman, Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, GAO assessed the controls that monitor the operations of such wells. In so doing, GAO

- evaluated whether and to what extent there is evidence that hazardous waste from underground wells has contaminated underground sources of drinking water,
- assessed EPA and state oversight of underground injection of hazardous waste, and
- determined what program changes are expected from an upcoming ban on the underground injection of hazardous waste.

Background

The generation of hazardous waste is a natural consequence of today's technological society. Such waste must be stored, treated, or disposed of. Three basic methods of disposal are surface impoundment, landfill, and injection into underground wells.

Liquefied hazardous waste is often injected into underground wells and deposited below drinking water supplies into porous rock formations that are separated from the drinking water by layers of nonpermeable rock. The nonpermeable rock reduces the likelihood of hazardous waste migrating upward and contaminating drinking water.

Hazardous waste has been injected into underground wells since the 1950s; until 1980, however, control and regulation of this activity resided solely with the states. In 1980, under authority provided by the Safe Drinking Water Act of 1974, EPA instituted the Underground Injection Control Program, through which it monitors injection wells either directly or through delegation to states referred to as "primacy" states.

At the time of GAO's review, this country had 181 active hazardous waste injection wells, 17 of which are commercial, disposing of waste generated by others for a fee. The remaining 164 "on site" wells are operated by firms that only dispose of waste they generate. About 86 percent of all active hazardous waste wells nationwide are located in 9 states having primacy; EPA exercises direct oversight over the remaining 14 percent of the wells located in 5 states that do not have primacy. Even in primacy states, however, EPA sets minimum acceptable standards of operation that must be met. We conducted our review in 6 states (4 primacy states and 2 states in which EPA directly regulates the wells), which contain 84 percent of this country's hazardous waste injection wells.

This report limits discussion of controls to well operations only. Other important safeguards, which were not the subject of this review, pertain to siting and permitting of wells. (See ch. 1.)

Results in Brief

There have been few confirmed cases of drinking-water contamination from hazardous waste injection wells. However, because the contamination is hard to detect, it cannot be said with certainty that no other cases exist. Although monitoring wells are a primary method of detecting contamination, they have limited usefulness for large underground areas. Neither EPA nor the states require that groundwater immediately above injected waste be sampled and tested for contamination. Two cases of drinking water contamination have been documented by the companies operating the wells.

The four primacy states that GAO reviewed are monitoring the operation of the injection wells themselves to assure compliance with current regulations and protect underground sources of drinking water. GAO found, however, that for the 21 wells in 2 states for which EPA has direct oversight responsibility, the agency—citing higher priorities—did not perform the required periodic inspections during fiscal years 1985 and 1986.

Effective in August 1988, underground hazardous waste injection will be banned except where it can be shown that the waste can be fully contained within the injection zone and will not spread into unintended areas; the burden of proof will fall on the well operator. EPA expects that, with few exceptions, wells operating today will be able to meet this test and will, therefore, continue to inject hazardous waste underground.

Principal Findings

Drinking-Water Contamination

The limited number of cases documented to date indicate that drinking-water contamination has not been extensive. Two documented cases of drinking-water contamination have been found, as have one case of suspected contamination and eight cases of documented contamination of water that was already considered unsuitable for drinking. Program controls now in place prohibit the practice that led to the two cases of drinking water contamination.

Because contamination is difficult to detect, it is not known whether or not the injection of hazardous waste has contaminated other underground water sources. EPA and the states do not require groundwater to be sampled and tested. This could be done by sinking wells to monitor the quality of underground water and the migration of contaminants, but there are disadvantages to this approach. The information such wells would yield is of limited usefulness for assessing large underground areas. In addition, such wells can themselves cause problems by creating other avenues for wastes to escape. Program changes currently contemplated by EPA do provide for installing monitoring wells, but only under certain conditions. (See ch. 2.)

Monitoring and Enforcement

EPA uses three interrelated program requirements to assure compliance with well-operating regulations. Mechanical integrity tests measure the operating soundness of the wells, including checking for leaks. Operator reports include information on the waste being injected; the well pressure, flow rate and volume; and report the degree of permittee compliance with these permit conditions. Periodic inspections determine the accuracy of operator self-monitoring and the adequacy of injected-waste sampling.

The four states having primacy that GAO reviewed meet or exceed minimum EPA program requirements for monitoring hazardous waste injection wells in that all three oversight mechanisms had been implemented and were being conducted at least as frequently as EPA requires. These mechanisms identified 92 incidents of noncompliance with program regulations at 42 of the 103 wells reviewed during fiscal years 1985 and 1986. For the remaining 61 wells, no noncompliance incidents were found during the 2-year period.

States have taken enforcement actions—such as letters requiring compliance within a certain period of time—to correct violations. Corrective actions had been taken by well operators for 95 percent of the 92 noncompliance incidents at the time of GAO's review. None of the violations were considered by EPA to threaten human health or the environment.

Periodic well inspections were not performed, however, during fiscal years 1985 and 1986 for 21 wells in 2 states for which an EPA regional office had program responsibility; the reason cited was higher priority work. In these states, EPA headquarters did not perform oversight evaluations of the regional office program that ensured that well inspections were performed. As a result, there is the potential that some wells may be operating that are not complying with program requirements. (See ch. 3.)

Ban on Underground Injection of Hazardous Waste

Legislation passed in 1984 mandates, among other things, the banning of injection well disposal of hazardous waste starting in August 1988 unless well operators can demonstrate that the waste will not migrate as long as it remains hazardous. EPA believes that sufficient information is known about what happens to injected waste for operators to demonstrate no migration. EPA expects that most wells now operating can successfully demonstrate no migration. However, some environmental groups do not believe that EPA's draft regulations implementing the ban assure no migration of injected waste. The draft regulations also tighten controls—such as yearly mechanical integrity testing rather than testing once every 5 years—over all hazardous waste injection wells. (See ch. 4.)

Recommendations

GAO recommends that the Administrator, EPA, strengthen EPA headquarters' oversight of each regional office operating an underground injection control program to ensure that inspections of hazardous waste wells are performed and documented. (See ch. 3.)

Agency Comments

GAO's findings were discussed with EPA officials during the course of the review, and changes were incorporated as appropriate. At the request of the Subcommittee Chairman, GAO did not ask that EPA comment officially on a draft of this report.

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Abbreviations

EPA	Environmental Protection Agency
GAO	General Accounting Office
MIT	mechanical integrity test
NIPER	National Institute for Petroleum and Energy Research
PENNDER	Pennsylvania Department of Environmental Resources
QNCR	quarterly noncompliance report
RCED	Resources, Community, and Economic Development Division
RCRA	Resource Conservation and Recovery Act
UIC	underground injection control

Introduction

About half of all Americans—and up to 95 percent of those in rural areas—rely on groundwater[1] as their principal source of drinking water. According to EPA, groundwater is becoming increasingly contaminated by many sources, including inappropriately disposed hazardous waste. Hazardous wastes, which pose a high risk to the environment because of their toxicity, are disposed of primarily by injection in specially designed wells deep underground.

To protect underground sources of drinking water from improper injection of waste, Congress passed Part C of the Safe Drinking Water Act in 1974. This law requires the Environmental Protection Agency (EPA) to establish an underground injection control (UIC) program to ensure that injected waste does not contaminate underground drinking water sources, and to set minimum standards for states to adopt in order to assume primary program responsibility. This report examines EPA and state oversight of the operation of hazardous waste injection wells under the UIC program.

Use of Injection Wells for Hazardous Waste Disposal

Injection wells have been used for waste disposal since the 1950s. About 290 million tons of hazardous wastes are generated in the United States each year. Of the hazardous wastes disposed of, most (59 percent) are injected as a liquid in specially designed deep wells. A large quantity (35 percent) are placed in surface impoundments such as pits, ponds, and lagoons; and a small portion (6 percent) are placed in landfills or are buried.

According to EPA, underground injection is generally less expensive than other disposal methods. For example, EPA estimates that disposal of hazardous waste by underground injection costs between $10 and $18 per ton at noncommercial facilities, while disposal in landfills costs between $50 and $500 per ton at noncommercial facilities.

Underground Injection Site Characteristics

Liquefied waste is injected into underground wells and deposited in porous rock formations deep underground, below drinking water sources. The waste is injected into a relatively permeable and porous formation that can accommodate additional fluid under pressure. The formation into which waste is deposited is called the injection zone. An

[1]Groundwater is subsurface water that saturates spaces between soil particles and rocks. Layers of sand, gravel, or rock-bearing groundwater are called "aquifers." Aquifers may be located near the surface or thousands of feet underground.

ideal injection zone is comprised of sedimentary rock with sufficient thickness, porosity, permeability, and a large enough area to accept the injected liquid. The geology of the zone should be uniform, and it should not contain any faults, fissures, or other channels through which the injected waste could flow.

Overlying the injection zone is much less permeable rock that separates the injected fluid from other formations, especially underground sources of drinking water.[2] This area is called a confining zone; it should be sufficiently thick and impermeable to provide a seal against the upward flow of injected fluid.

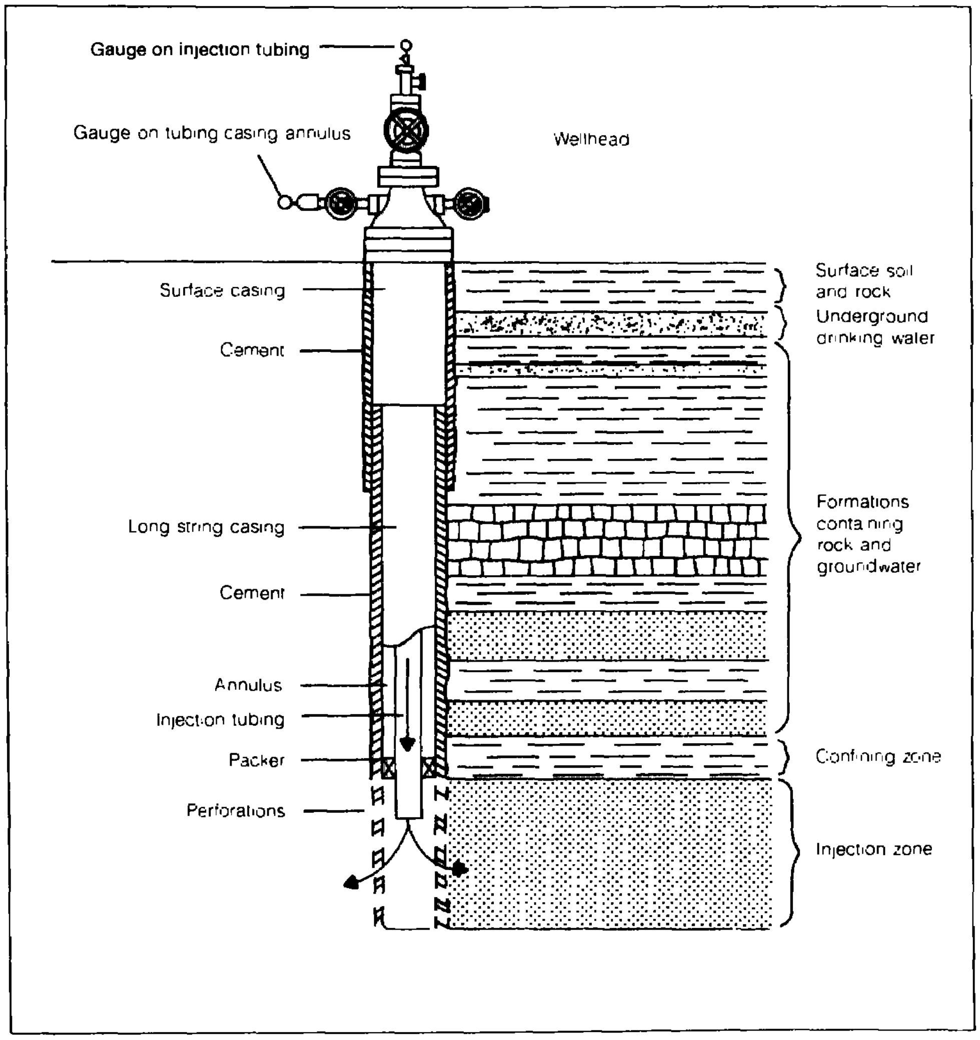
Most underground injection wells are located along the Gulf Coast and around the Great Lakes. Common to these regions are thick sedimentary rock formations and a geology that is relatively well understood because of extensive drilling for oil and gas. According to EPA, wells in the Gulf Coast area are typically deeper than those in the Great Lakes region. The average injection well in the Gulf Coast region is about 4,600 feet deep and waste is injected about 3,300 feet below the lowermost underground source of drinking water. By contrast, the average injection well in the Great Lakes region is just under 2,500 feet deep and waste is injected about 2,300 feet below the lowermost underground source of drinking water.

Injection Well Technology

A typical injection well used for hazardous waste disposal consists of concentric pipes inserted into a well bore. (See fig. 1.1.) The outer pipe, or surface casing, usually extends below the base of usable water and is cemented to the surface. Within the surface casing are two pipes that extend to the injection zone—the long string casing (usually cemented back to the surface) and the innermost injection tubing. Waste is injected through the injection tubing and exits through perforations at the bottom of the tubing. The space between the tubing and the long string casing, called the annulus, is closed off at the bottom by a packer, a device that keeps injected fluids from entering the annular space. The annular space is typically filled with a pressurized fluid that is kept at a higher pressure than the fluid being injected, to prevent waste from escaping into the annulus if a leak occurs in the injection tubing. The surface portion of the well contains valves and gauges to control and monitor injection and annular pressure.

[2]EPA defines an underground source of drinking water as a water-bearing formation containing less than 10,000 milligrams per liter of total dissolved solids

Figure 1.1: Typical Hazardous Waste Disposal Well



Source: Based on B. Klemt, et al., "Industrial Waste Disposal Wells: Mechanical Integrity," Proceedings of the International Symposium on Subsurface Injection of Liquid Wastes, New Orleans, La., 1986, p. 93.

Note: This figure is not drawn to scale. A typical injection well is between 2,000 and 4,000 feet deep.

Users of Hazardous Waste Injection Wells

The biggest users of hazardous waste injection wells are the chemical and petroleum industries, which dispose of three-quarters of all injected hazardous waste. EPA estimates that 11.5 billion gallons of hazardous waste were injected in 1983 (the most recent year for which data are available). About one-half of this volume was generated by the organic

chemicals industry. Table 1.1 breaks down the total volume of hazardous waste disposed by industry through injection wells.

Most hazardous waste injection wells are owned and operated by the waste generators themselves and are located at the site of the generating facility. Only 4 percent of the total injected volume is handled by commercial waste disposers, which represent 9 percent of the wells. They are classified as "off-site" wells because they inject hazardous waste—for a fee—that has been generated by others at other locations.

Table 1.1: Users of Hazardous Waste Injection Wells

Industry	Percentage of waste injected	Percentage of wells
Organic chemical	51	44
Petroleum refining	25	20
Other chemical manufacturing	13	18
Metals and minerals	6	8
Commercial disposal	4	9
Aerospace	1	1
Total	**100**	**100**

Waste Characteristics

Hazardous waste must be liquefied before it can be injected. Of the 11.5 billion gallons of hazardous waste injected in 1983, EPA estimates that less than 4 percent (423 million gallons) was waste; the remainder was water that it was mixed with. No nationwide data characterizing the waste currently injected are available. The best data available were collected by EPA in 1983 for 60 percent of the hazardous waste wells. These wells disposed of 228 million gallons of waste mixed with over 6 billion gallons of water. About half of the 228 million gallons of waste was comprised of hazardous compounds (48 percent) and half was comprised of nonhazardous inorganic compounds (52 percent). The hazardous compounds were predominantly acids (41 percent) and organic compounds (36 percent), with small proportions of heavy metals (1 percent) and inorganic compounds (1 percent). Twenty-one percent of this hazardous waste was classified as miscellaneous other compounds.

Most hazardous waste is treated before being injected to facilitate the injection process. A 1985 study by EPA indicated that a large majority of hazardous waste operators use physical or physical-chemical processes to remove suspended solids prior to injection. Treatment is also used to make the injected waste compatible with fluids already in the geologic

formation and with other injected fluids to avoid undesirable chemical reactions in the injection zone and in the well itself.

Federal Regulation of Underground Hazardous Waste Injection

The Safe Drinking Water Act of 1974 and the Resource Conservation and Recovery Act (RCRA) of 1976 are the primary laws governing the disposal of hazardous waste by injection in wells. The Safe Drinking Water Act required EPA to establish the UIC program to regulate all injection wells, and RCRA charged EPA with organizing a program to regulate the management of hazardous waste. The RCRA program has jurisdiction over all hazardous waste surface facilities, including injection sites. The UIC program has jurisdiction over hazardous waste disposal once the waste enters the injection well.

Primary Legislation Affecting Hazardous Waste Injection

To ensure the protection of the nation's underground sources of drinking water from improper injection of fluids, the Congress established the UIC program in Part C of the Safe Drinking Water Act of 1974. This law charged EPA with setting permitting and operating requirements for all underground injection facilities and minimum standards and technical requirements that states could adopt to assume primary permitting and enforcement responsibility ("primacy"). EPA issued final UIC program regulations in 1980.

RCRA required EPA to develop and implement a regulatory program to control hazardous wastes "from cradle to grave." In fulfilling this statutory mandate, EPA promulgated regulations in 1982 identifying hazardous wastes and establishing minimum requirements for their generation, transportation, treatment, storage, and disposal.

The 1984 Hazardous and Solid Waste Amendments to RCRA prohibit land disposal of hazardous waste and, beginning in August 1988, underground injection disposal, unless the waste is pretreated to standards set by EPA or unless the owner or operator demonstrates that the waste will not migrate from the disposal unit or injection zone as long as it remains hazardous. These amendments and the changes they will lead to in the UIC program are discussed in chapter 4.

The Safe Drinking Water Act amendments of 1986 require EPA to, among other things, identify and assess methods of monitoring injected substances that may migrate into or in the direction of underground drinking water. These requirements apply only to certain wells, including those used to dispose of hazardous waste.

UIC Program

The UIC program was implemented in 1980, when EPA issued final regulations. These regulations established five classes of injection wells. Class I wells are used to dispose of hazardous waste and nonhazardous industrial and municipal waste below the deepest underground sources of drinking water. Class II wells, which include the vast majority of injection wells, are used during oil and gas production for waste disposal or oil recovery. Class III wells are used for special processes, such as mining minerals. Class IV wells, which inject hazardous waste into or above underground sources of drinking water, are illegal; all were required to be plugged by May 1985. Class V wells are nonhazardous waste injection wells that do not fit into the other four classifications.

Table 1.2 shows the number of wells in each class as of 1985. Of the 533 class I wells, only 181 were active hazardous waste injection wells.[3] Class I hazardous waste wells are the subject of this report.

Table 1.2: Number of Injection Wells in Each Class

Class	Number of wells
I	533
II	153,126
III	249
IV	25
V	46,271
Total	**200,204**

The 1980 regulations also established minimum technical requirements for injection wells, designed to ensure that the waste will be injected in the proper formation and remain there. These requirements (which apply to all well classes) cover permitting, operating, monitoring, and reporting for active wells; and plugging and abandonment of inactive wells.

All wells used to inject hazardous waste are required to have a UIC permit, which may be issued or reissued for up to a 10-year term. The permit specifies construction, operating, abandonment, monitoring, and reporting requirements. Additionally, permits include compliance schedules if any corrective action needs to be taken by the well owner or operator. Permit applications generally include information such as surficial and subterranean features of the injection area, the location of nearby

[3]As of July 1987, there are 186 active hazardous waste injection wells, according to EPA officials.

underground sources of drinking water, the results of tests in the proposed injection formation, construction features of the well, composition of the injected fluid, and the nature of the proposed injection operation.

The UIC program also includes operating requirements designed to prevent groundwater contamination. In general, all injection wells have a limitation on the injection pressure. This limitation is set below the pressure needed to create or enlarge fractures in the injection or confining zones. All wells are also required to operate with a pressurized annulus filled with noncorrosive fluid.

The regulations also require a well's owner or operator to assure, through a performance bond or other means, the financial resources to properly plug and abandon a well at the end of its service life. The financial assurance is submitted as part of the permit application. The UIC regulations do not require the operator to monitor groundwater after a well has been abandoned or place any time limits on or requirements for subsequent care of a plugged and abandoned well.

The UIC program established monitoring and reporting requirements designed to ensure that a well is not leaking and is operating within the limits set in its permit. The primary monitoring devices are mechanical integrity tests, well operator reports, and periodic inspections.

Mechanical integrity tests are a series of tests used to determine whether a well has sound operating components. Specific tests measure for leaks in the casing, injection tubing, and packer; and channels in the cement seal encasing the outer pipe that would prevent leaks from an underground formation into an underground source of drinking water. Mechanical integrity tests are required for new wells prior to operation and at least every 5 years thereafter. Generally, wells that fail mechanical integrity tests are temporarily closed until repairs have been made and a subsequent test passed.

Well operators are required to submit reports quarterly to their permitting authority (the states or in some cases EPA regional offices) that include an analysis of injected fluids and monthly average injection pressure, flow rate, and volume. Operators must also report the results of all mechanical integrity tests and major repairs that may have been performed. These reports are reviewed by state or EPA regional UIC staff to ensure that permit conditions related to these characteristics are being met.

The regulations require the permitting authority to inspect hazardous waste injection well facilities at least annually. The purpose of the inspections is to determine compliance with permit conditions, to verify the accuracy of information submitted in operator reports, and to verify the adequacy of sampling and monitoring.

To ensure that the program requirements are being met, EPA regions oversee state activities by making on-site evaluations of state programs at least annually and by requiring states to submit quarterly noncompliance reports. The noncompliance reports provide EPA with information about the types of noncompliance incidents occurring and actions taken by state officials to ensure compliance.

These requirements became applicable to injection wells in a particular jurisdiction when EPA approved a state's UIC program or promulgated a federally implemented program for a state. For a state to have a federally approved underground injection control program, it must meet these minimum standards. In cases where EPA implements the program in a state, it is subject to the same minimum standards. Between 1982 and 1985, EPA issued regulations that granted 35 states and territories primary responsibility for class I wells. In 1984 EPA issued regulations assuming responsibility for implementing the program in the remaining 22 states, territories, and the District of Columbia.

Table 1.3: Status of Federally Approved UIC Programs for States With Active Hazardous Waste Injection Wells

State	Date program became effective	Program implemented by: state	Program implemented by: EPA	Number of active wells
Texas	Feb 7, 1982	X		68
Louisiana	Mar 23, 1982	X		54
Arkansas	July 6, 1982	X		2
Oklahoma	July 24, 1982	X		4
Florida	Mar. 9, 1983	X		1
Alabama	Aug. 25, 1983	X		2
Kansas	Dec. 2, 1983	X		5
Illinois	Mar. 3, 1984	X		6
Alaska	June 25, 1984		X	1
California	June 25, 1984		X	1
Indiana	June 25, 1984		X	8
Kentucky	June 25, 1984		X	2
Michigan	June 25, 1984		X	13
Ohio	Jan. 14, 1985	X		14
Total				**181**

As of April 1987, only 14 states had active hazardous waste injection wells. Table 1.3 lists these states and indicates those with primary responsibility and those with EPA program responsibility for class I hazardous waste wells. The 9 states with federally approved programs include 86 percent of the 181 active hazardous waste injection wells. Prior to EPA's approval of these programs, states were not subject to federal regulations.

RCRA Program

In addition to requirements under the UIC program, injection wells used for hazardous waste disposal must have a RCRA permit. In regulations issued in 1982, EPA determined that hazardous waste injection wells permitted under the UIC program would be granted RCRA "permits-by-rule."[4] However, any other hazardous waste treatment, storage, or disposal unit located at the injection well site is subject to full permitting under RCRA.

Objectives, Scope, and Methodology

The Chairman, Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, in his letter of March 3, 1986, requested that we evaluate how EPA is managing the disposal of hazardous waste through underground injection. In subsequent discussions with his office, we agreed to review the following:

- What evidence exists that hazardous waste disposed of in underground wells has contaminated drinking water.
- EPA and state oversight of the operation of hazardous waste injection wells.
- UIC program changes expected as a result of disposal restrictions imposed by the 1984 RCRA amendments.

In reviewing contamination of drinking-water sources by hazardous waste injection wells, we searched for case studies of contaminated sites and examined how contamination was detected. We did not restrict the cases we examined to any particular time period. We divided the case studies into three categories: documented cases of drinking-water contamination, cases in which an injection well is the suspected cause of

[4]A facility is deemed to have a RCRA permit-by-rule if it is permitted under the Safe Drinking Water Act and complies with several other requirements, including reporting and recordkeeping for hazardous waste, training, and certification of well closure.

contamination, and documented cases of nondrinking-water[5] contamination. For the last category, we looked for evidence that the contamination might spread to drinking-water sources.

Our review of EPA and state oversight of hazardous waste injection wells included monitoring and enforcement activities, and, as agreed to by the requester's office, did not include permitting activities. In reviewing these activities, we examined the roles of EPA and states in inspecting and monitoring the injection of hazardous wastes and enforcing compliance with the UIC regulations, how EPA and states are monitoring injection well operations, and how they are enforcing compliance with the UIC regulations.

In reviewing program changes expected as a result of the 1984 ban on underground injection of hazardous waste, we examined the conditions under which well operators will be allowed to continue disposing of hazardous waste, what is known about the fate of injected wastes that makes EPA officials believe that hazardous waste can continue to be safely injected, and the expected effects of the 1984 amendments on disposing of hazardous waste through underground injection.

To address these issues, we gathered information from six states: Illinois, Indiana, Louisiana, Michigan, Oklahoma, and Texas. These six states were selected randomly, with a probability of selection proportionate to the number of wells located in each state. These states have 84 percent of the total number of hazardous waste injection wells in this country. In Michigan and Indiana, the program is implemented by EPA; the other four states run their own programs.

Our work was conducted from May 1986 through April 1987. We collected information for all active hazardous waste injection wells in Illinois, Indiana, Louisiana, Michigan, and Oklahoma for fiscal years 1985 and 1986. We collected information for 39 of the 68 hazardous waste wells in Texas, including all 8 commercial wells and 31 of the remaining wells, which we selected randomly. The information we collected included the number of inspections, results of operator reports, and mechanical integrity test results; and the number and types of violations and enforcement actions taken. This information was gathered from quarterly operator reports, quarterly noncompliance reports submitted

[5]Water not classified by EPA as drinking water because it contains 10,000 milligrams per liter or more of total dissolved solids

by the states to EPA, and inspection reports. We did not verify the information contained in these documents.

We also interviewed state UIC program staff, EPA regional and headquarters staff, geologists conducting injection well research at Kerr Environmental Research Laboratory, other environmental researchers, and well operators. In addition, we reviewed published reports, draft federal regulations, and other state and EPA documents. We also attended meetings of the Underground Injection Practices Council—a trade association whose members come from industry, environmental organizations, and federal and state UIC programs—and UIC rulemaking sessions, which developed preliminary drafts of proposed changes to the UIC regulations.

The views of EPA and state officials directly responsible for the UIC program were sought during our review and are incorporated into the report where appropriate. In accordance with the wishes of the Chairman's office, we did not request EPA or the state authorities included in our review to officially comment on a draft of this report. We performed our review in accordance with generally accepted government auditing standards, except for the limitation noted above.

Has Injected Hazardous Waste Contaminated Underground Sources of Drinking Water?

The full extent to which injected hazardous waste has contaminated underground sources of drinking water is unknown. There have been only two documented cases of contaminated drinking water, one additional case of suspected contamination, and eight documented cases of nondrinking-water aquifer contamination. All of the documented cases of drinking- and nondrinking-water contamination, however, involved well malfunctions that led to contamination around the well-bore, where it is relatively easy to detect. The suspected case occurred away from the well-bore, where identification of the source of such contamination is difficult. No cases of groundwater contamination resulting from underground channels—as opposed to malfunctioning wells—have been confirmed, but such contamination would be more difficult to detect if it did not produce effects on the surface.

A reliable method for sampling and testing sizable underground areas for contamination from injected waste has not been found. Consequently, although EPA and the states have the authority to require monitoring in individual cases, neither organization requires such sampling and testing at all facilities. Program control changes currently contemplated by EPA provide for installing monitoring wells (wells drilled mainly to periodically measure water quality) at some injection well sites.

The causes of past contamination are now better understood; control mechanisms are currently in place under EPA's UIC program (which states began implementing between 1982 and 1985) that prohibit the practice that led to the two cases of drinking-water contamination. UIC program controls planned for the future will be more stringent.

Contaminated Sites

According to EPA studies, cases where injected hazardous waste contaminated underground drinking water sources were documented in Louisiana in 1980 and in Texas in 1975. In addition, drinking-water contamination whose source was suspected to be injected waste (although never proved) occurred in Pennsylvania in the early 1970s. There have also been eight cases where injected hazardous waste contaminated nondrinking-water sources. (For the nondrinking-water cases, EPA does not expect contamination to migrate into the drinking water.) On two other occasions, well blowouts caused contamination of surface soil.[1]

[1] A well blowout is a sudden, violent expulsion of fluid, gas, and mud from the well, followed by an uncontrolled flow of injected fluid from the well

The following information provides examples of why contamination occurred and the types of corrective action taken.[2]

Drinking-Water Contamination in Louisiana

Leakage of injected waste caused contamination of an underground drinking water source at Tenneco Oil Company's well no. 1 in Chalmette, Louisiana, in 1980. The contamination was confined to within a 100-foot radius of the disposal well in the uppermost portion of the drinking-water aquifer. Tenneco's restoration efforts, begun in 1982, had substantially reduced the contamination levels by early 1986 and will continue until the area is restored to acceptable standards of safe drinking water, since this aquifer is so heavily used in the New Orleans area. As of May 1987, Tenneco had spent about $400,000 on restoration and will incur additional costs of about $60,000 per year until restoration is complete.

Drinking water in the Chalmette area is contained in five aquifers, which extend from a depth of about 100 feet to a depth of 1,200 feet. Louisiana issued a permit for well no. 1 to pump oil-refinery wastewater containing phenols, sulfides, ammonia, and organic carbons into a sand reservoir located about 1,900 feet below the surface. The injection zone is 900 feet below the lowest drinking-water aquifer and is separated from it by a shale confining zone approximately 70 feet thick. The well was constructed without tubing and packer and waste was injected directly through the casing.

In June 1980 the operator discovered that well no. 1 was leaking: injected wastes were found on the surface near the well. The well was immediately taken out of operation, and pressure tests conducted in February 1981 confirmed that the well casing—through which the wastewaters were pumped into the injection zone—was leaking at depths of between 140-147 feet and between 160-212 feet. The well was abandoned on February 26, 1981, after cementing in the bore-hole.

The Louisiana Office of Conservation conducted a groundwater contamination investigation to determine the extent to which contamination had

[2]Most of the information was obtained from a 1986 study of noncompliance incidents at hazardous waste injection wells conducted for EPA (Class I Hazardous Waste Injection Wells. Evaluation of Noncompliance Incidents by Engineering Enterprises, Inc., et al., draft). However, data from the study were verified and supplemented by information from other EPA- and industry-prepared studies (Report to Congress on Injection of Hazardous Waste, EPA Office of Drinking Water, May 1985 and A Class I Injection Well Survey prepared for the Underground Injection Practices Council by CH2M Hill, April 1986) and by telephone contacts with EPA regional offices, state UIC offices, and injection well operators

occurred. To assess this, 14 monitoring wells were installed starting in January 1982—6 in the "100-foot" aquifer, 6 in the "200-foot" aquifer, and 2 in the "700-foot" aquifer. This monitoring revealed that contamination occurred only in the "100-foot" aquifer and was confined to an area within 100 feet of the well-bore. The contaminate leakage was believed, therefore, to have migrated upward along the well-bore because no contamination was found in the two lower aquifer levels monitored.

A groundwater recovery system was installed. Between July 1982 and early 1986, the system had removed about 250,000 barrels of contaminated water and reduced the phenol level, used as the contamination indicator, from 1,600 to 13 parts per million. The recovery operation is expected to continue until an acceptable contamination level is achieved. That level had not been established as of April 1987.

Drinking-Water Contamination in Texas

Leakage of Velsicol Chemical Corporation's well no. 1 caused contamination of drinking water near Beaumont, Texas, in 1975. The leak and corresponding contamination occurred at a depth of 665 to 680 feet in the lower Chicot aquifer. The extent of contamination was limited to this area. Remedial action consisted of aquifer restoration, in which a monitoring well, pumping for 90 days, reduced the contamination to acceptable levels.

Casing leaks in the well were discovered by mechanical integrity testing (see ch. 3) in June 1975, and the well immediately stopped operation. The well was then plugged, and a monitoring well installed between August and September 1976 to pump out the contamination. After the contaminated waste was removed, another monitoring well was drilled about 50 feet away; water samples from this well showed that the contamination had not spread to that area.

As with the Tenneco well in Louisiana, this well was constructed without packer and tubing, with injection occurring directly through the casing.

In both of these cases of known drinking-water contamination, the practice of allowing injection directly through the casing was the primary cause of the leakage. This practice is not permitted under present UIC regulations. Another safety feature required by current standards is double casing and cementing that extends below the base of the drinking-water zone.

Suspected Drinking-Water Contamination in Pennsylvania

In the early 1970s, complaints about a foul-smelling liquid seeping from an abandoned gas well in Presque Isle State Park near Erie were received by the Pennsylvania Department of Environmental Resources (PENNDER). Waste from the Hammermill Paper Company injection wells, which were located about 5 miles west of the abandoned gas well, were suspected by PENNDER to have migrated up the unplugged well-bore of the gas well, causing drinking-water contamination.

The Hammermill injection wells were having operational problems at the time; all wells were plugged and abandoned in September 1972 as a result of casing corrosion. No drinking-water contamination occurred at the well site as a result of the Hammermill injection well problems. Field tests and investigations conducted by PENNDER and by EPA between 1979 and 1982 failed to determine the source of the fluid seeping from the abandoned gas well. The fluid was similar to "black water,"[1] which is found in deep formations in the area. To date, no conclusive evidence has been found that links the fluid that seeped from the Presque Isle well to the Hammermill injection wells.

Nondrinking-Water Contamination

EPA studies also indicate, in addition to these cases, that hazardous waste leakage into nondrinking-water aquifers has occurred at eight facilities. Injection operations have also caused soil contamination at two other facilities. Contaminants from these ten incidents are not expected to migrate to an extent that would pose a threat to drinking-water aquifers.

Leakage from hazardous waste injection wells into nondrinking-water aquifers occurred at eight facilities between 1975 and 1984. Contaminants entered areas not allowed by the wells' permits, but which were nondrinking-water zones. The problems, generally disclosed or confirmed by mechanical integrity tests, centered on casing and/or tubing corrosion or deterioration.

The most notable of these cases occurred at a commercial facility in Ohio in 1983. The operators did not discover leaks in the bottom part of the casing of their wells until large amounts of waste escaped into an unpermitted zone. This zone was, however, separated from the bottom of the lowermost drinking-water aquifer by more than 1,500 feet—1,000 feet of which was confining rock formations. According to EPA, the

[1] Naturally occurring formation water containing iron sulfides caused by the reaction between hydrogen sulfide and metals in the water.

drinking water remained uncontaminated. This problem was detected during the mechanical integrity test conducted to obtain information for a UIC permit. The operator was fined $12.5 million for these and other violations; the problem wells have been repaired.

On two other occasions, well blowouts caused surface soil contamination. In one case, corrosion caused the tubing to part, causing the well to blow out and allowing the waste to flow to the surface. In the other case, several blowouts occurred during major maintenance operations. The blowouts were believed to have been caused by carbon dioxide gas that was thought to have been generated during these operations. The contaminated soil was cleaned up at both of these sites, and no drinking water was contaminated. Both of these wells have been plugged and abandoned because of continued operating problems.

EPA officials believe that incidents such as these will not occur in the future if current regulations are properly followed.

Difficulties in Discovering Contamination

The full extent to which injected hazardous waste has contaminated underground sources of drinking water is unknown because of the problems in determining if contamination has occurred. The UIC program emphasizes prevention rather than after-the-fact monitoring to assure that wastes do not contaminate groundwater. The program has control mechanisms and procedures to prevent and detect possible sources of contamination near the well-bore because of malfunctions in the well structure or mechanisms. However, methods currently available for discovering contamination that might occur away from the well-bore through underground leakage yield limited data and have several disadvantages. New controls contemplated by EPA at some injection wells include a requirement to install monitoring wells to take groundwater samples and analyze them for constituents.

The most common potential causes of contamination near the well-bore are breaches in the casing, tubing, and packer; and fissures, channels, or insufficient cement in the space between the bore-hole walls and the casing. Most well contamination cases discussed in this report resulted from problems near the well-bore; leaks were either identified or confirmed by mechanical integrity tests, one of the oversight mechanisms discussed in chapter 3.

Contamination that occurs away from the well-bore is more difficult to detect. This type of contamination results from wastes that migrate

through faults or fractures and unplugged man-made holes that penetrate the injection zone. Current UIC regulations require that injection wells not be located in areas where faults occur and that injection pressures be maintained below a level that might cause fractures in the formation. Regulations also require that all man-made holes in the area—a fixed radius of one-quarter mile around the well or a radius calculated using a formula—penetrating the confining zone and entering the injection zone be located and properly plugged. However, while continuous monitoring of injection pressure gives some indication that injected fluid may be escaping the injection zone (and when further investigation of possible contamination may be warranted), unless contamination is detected by a monitoring well or drinking-water well, signs of contamination must appear at the surface before contamination can be detected.

Monitoring wells have been used successfully to measure the extent of contamination in the general area where contamination has already been identified. However, these wells have not been used extensively to detect possible contamination at lower depths by deep-well injection and are not required by EPA's UIC program regulations or by the states we reviewed. According to studies by industry and state regulatory authorities, several factors explain this:

1. Monitoring wells sample underground water from a very small area. This limits their ability to assess large underground areas

2. The several confining layers and potential injection zones between the point of injection and the drinking water make it difficult to predict migration pathways. This fact, coupled with the fact that monitoring wells can only sample from a small area, makes proper siting of monitoring wells difficult.

3. Numerous geological investigations support the conclusion that thick natural confinement systems prevent vertical migration. Most hazardous waste injection wells have thick confinement systems because waste is typically injected into deep, subsurface formations providing large, vertical separation from the lowermost underground sources of drinking water.

4. Deep monitoring wells themselves create potential routes by which contaminants—naturally occurring or injected—can reach drinking water.

The Congress has shown concern for this problem: the 1986 amendments to the Safe Drinking Water Act directed EPA to identify additional groundwater-monitoring methods and determine the applicability of such methods to deep-well injection. The proposed program regulations that were drafted in response to the act and that will take effect in August 1988 currently call for more stringent operating requirements, including installing a monitoring well in the first formation overlying the confining zone of some injection wells. See chapter 4 for a discussion of this proposed program control change.

Conclusions

The full extent to which injected hazardous waste has contaminated underground sources of drinking water is unknown because of problems in detecting contamination that may have occurred away from the well-bore. A monitoring method for sampling and testing sizable underground areas of groundwater for contamination has not been found.

The limited number of cases documented to date do not indicate that contamination has been extensive. However, the documented cases of contamination have all occurred around the well-bore. UIC regulations now in place prohibit the practices that led to the two cases of drinking-water contamination discussed in this chapter. As discussed in chapter 4, additional controls planned for the future will be more stringent.

Protection against contamination also requires an effective oversight structure. The methods by which states and EPA oversee the underground injection of hazardous waste—and their results—are examined in detail in chapter 3.

State Oversight of Injection Well Operations Assures Program Compliance, but EPA Oversight Needs Strengthening

EPA requires that states that regulate hazardous waste injection wells employ certain oversight mechanisms and procedures. The four states we reviewed with this regulatory responsibility met or exceeded EPA's requirements. EPA itself, however, has not fully implemented oversight controls in the two states we reviewed for which it bears direct responsibility.

EPA's UIC program is designed to protect underground sources of drinking water by assuring that wells are operating within their permitted limits for injection volume and pressure, that only authorized hazardous waste materials are injected, and that all well components and monitoring equipment are in sound operating order. The program includes mechanisms and procedures to detect and correct incidents of noncompliance with these operating requirements before they become environmentally or health threatening. Detection of noncompliance incidents is accomplished through an interrelated system of injection well tests, operator reporting, and inspections. Correction of noncompliance incidents is accomplished through enforcement programs run by the primacy states or EPA regions and overseen by EPA regions and headquarters, respectively.

This system identified 92 incidents of noncompliance with program regulations at 103 wells in the 4 primacy states we reviewed during fiscal years 1985 and 1986. None of these incidents was serious enough to threaten the environment or health, and 95 percent had been corrected by the end of fiscal year 1986.

Periodic well inspections were not being performed during fiscal years 1985 and 1986, however, in the two states in our review for which EPA carries program responsibility. EPA said that higher priority work had prevented the performance of the inspections. These two states have 21 active hazardous waste wells. As a result, the possibility exists that UIC program requirements were not being complied with and potential deficiencies were not being corrected.

States Are Complying With Monitoring Requirements

The three primary oversight mechanisms used to protect underground drinking water are mechanical integrity tests (MITS), well operator reports, and periodic inspections. EPA has set minimum requirements for each, and the four state programs we reviewed have set requirements that are at least as stringent. (See table 3.1.) EPA will be issuing regulations, to take effect in August 1988, that should provide additional safeguards to protect underground sources of drinking water from

contamination by injected hazardous waste. These draft regulations provide for, among other things, different and more frequent mechanical integrity tests and changes in reporting requirements. These draft regulations are discussed in chapter 4.

Table 3.1: Oversight Mechanisms and Frequency of Requirements

Program and type of well	Mechanical integrity tests	Operator reports	Periodic inspections
Federal	Every 5 years	Quarterly	Annually
Texas			
On-site	Every 5 years	Quarterly	Semiannually
Commercial	Annually	Quarterly	Quarterly
Louisiana			
On-site	Every 5 years	Quarterly	Semiannually
Commercial	Annually	Quarterly	Quarterly
Illinois[a]			
On-site	Case-by-case basis with 5 year maximum interval	Quarterly	Annually to quarterly (case-by-case basis)
Oklahoma			
On-site	Every 5 years	Quarterly	Annually
Commercial	Every 5 years	Quarterly	Semiannually

[a]No commercial wells are currently operating in Illinois

During fiscal years 1985 and 1986, the four states in our review operating a UIC program complied with program monitoring requirements. The specific approaches taken to oversee activities in each of the four states varied, but each state utilized the interrelated oversight mechanisms of testing, operator reporting, and inspecting. The approach used and the specific results for each state's oversight mechanisms follow.

Texas

Texas has the largest number of active hazardous waste wells of any state (68), and was the first state to obtain UIC program primacy (Feb. 7, 1982). The program is operated by the Texas Water Commission. Four staff members, trained geologists, operate the program, and all have been with the Texas program for at least 5 years. Each staff member has responsibility for all segments of the program (inspections, reviewing operator reports, permitting, etc.) for an assigned number of wells.

MITS were performed on all of the wells reviewed in Texas; all wells passed. Similarly, operator reporting requirements had been established, and reports were received and reviewed. A periodic inspection program plan had been prepared, and scheduled inspections were conducted.

Louisiana

Louisiana has the second largest number of hazardous waste wells (54), and was the second state to obtain primacy (Mar. 23, 1982). The UIC program is operated by the Louisiana Office of Conservation. The UIC office is divided into three sections: geology, well status, and inspection and enforcement. Oversight of the operation of hazardous waste wells is handled by the inspection and enforcement section, which is staffed by 12 inspectors who have responsibility for all classes of wells (including nonhazardous). Entry-level inspectors are required to have at least 3 years' experience in oil and gas exploration or production work.

All wells currently operating in Louisiana had passed MIT requirements. However, two wells were temporarily out of service because of excess injection capacity at the facility. The wells will not be placed into service until they are tested. Another well was closed, awaiting plugging and abandonment because the injection formation had filled up. Operator reporting requirements had been established, and reports were received and reviewed. Here, as in Texas, a periodic inspection program was in place, and scheduled inspections were performed.

Illinois

Illinois has six active hazardous waste injection wells; it received primacy under the UIC program on Mar. 3, 1984. The program is administered by the Illinois Environmental Protection Agency. The agency has four inspectors, all trained geologists, who handle the UIC inspection and enforcement program. These inspectors are also responsible for RCRA inspections performed by the agency.

Three Illinois wells were tested and successfully passed MITs, and three had been shut down because of MIT failures. Two of these wells will be allowed to reopen as soon as repairs are made; one will be plugged and abandoned. Operator reporting requirements had been established, and reports were received and reviewed. A periodic inspection program was in place, and scheduled inspections were performed.

Oklahoma

Oklahoma has only four active hazardous waste wells and was granted primacy on July 24, 1982. The program is administered by the state's Department of Health. One individual handles most UIC program responsibilities in addition to other related duties within the Department's solid waste division.

All four Oklahoma wells conducted and successfully passed required MITS. Operator reporting requirements had been established and reports

were received and reviewed. A periodic inspection program was in place, and scheduled inspections were performed.

Noncompliance Incidents Identified

The noncompliance incidents reported during the 2-year period covered by our review were all related to well operation and maintenance and were not considered environmentally or health threatening by either EPA or the states. Sixty-one (59 percent) of the 103 wells we reviewed in the four primacy states had no reported incidents of noncompliance in fiscal years 1985 and 1986. For the remaining 42 wells, the states reported 92 noncompliance incidents to EPA on quarterly noncompliance reports (QNCRS). These reports, which show the type of noncompliance and the actions taken or planned to ensure compliance, are required by EPA for its use in monitoring the UIC program. The reported incidents were identified by the state during its review of operator reports and periodic inspections. Table 3.2 shows the types of noncompliance and the frequency of occurrences.

Table 3.2: Type and Frequency of Noncompliance

Type of noncompliance	Number of incidents
Defective recording device	32
Defective gauge	13
Deficiency in operator reporting	11
Annulus and/or injection pressure too high or too low	11
Minor wellhead or gauge leaks	9
Other	16
Total	**92**

Enforcement Actions Taken for Program Noncompliance

The four primacy states included in our review took enforcement actions to correct all noncompliance incidents reported to EPA during fiscal years 1985 and 1986. Table 3.3 shows the time taken to initiate the first enforcement action on each noncompliance incident.

Table 3.3: Number of Days Taken to Initiate First Enforcement Action

Number of days	Number of enforcement actions	Percentage of enforcement actions
0	51	56
1-14	27	29
15-30	2	2
31-60	8	9
61-90	0	0
91+	4	4
Total	**92**	**100**

First enforcement actions took place the day the incident was noted for 56 percent of the noncompliance incidents. The first enforcement action taken by state inspectors when they note a noncompliance incident during an inspection is usually a verbal notification during the closeout conference. Typically, inspectors then notify the well operator of the noncompliance by letter. For 85 percent of the incidents, first enforcement action was initiated within 14 days. On four occasions, the first enforcement action was not taken for over 90 days because of ongoing negotiations concerning prior noncompliance incidents. Depending on the severity of the noncompliance and the operators' actions to correct them, additional enforcement actions may be taken, such as the imposition of fines, lawsuits, and requiring the well to be shut down.

Table 3.4 shows the frequency of various enforcement actions for the 92 noncompliance incidents in the four primacy states. The individual categories total more than 92 because more than one enforcement action was taken on some violations.

Table 3.4: Enforcement Actions Taken by Primacy States

State	Letter	Verbal	Fine	Referred for legal action	Well shut down
Louisiana	21	4	3	0	4
Texas	46	49	0	9	0
Illinois	12	2	0	0	0
Oklahoma	0	0	0	1	0
Total	**79**	**55**	**3**	**10**	**4**

As of September 30, 1986 (the date of last QNCR we reviewed), corrective or final action had been completed for 87 of the 92 incidents. The five unresolved incidents involved

- three cases in Illinois where new well-monitoring equipment malfunctioned, causing noncompliance to continue longer than expected;
- an incident in Louisiana where the source of a slight loss of annulus pressure during testing had not been determined; and
- a case in Louisiana where an MIT failure has kept the well shut down and in noncompliance for an extended period.

For 59 of the 87 incidents that had been corrected, the QNCR reports reflected the dates that corrective or final action had been taken. Table 3.5 shows the time required to obtain corrective or final action for each of the 59 incidents. The undated actions for the other 28 incidents were completed during the same quarterly reporting period in which the incident occurred, which means they were completed in 90 days or fewer.

Table 3.5: Number of Days Taken to Obtain Corrective Action or Final Disposition

Number of days	Number of incidents	Percentage of incidents
0	6	10
1-14	15	26
15-30	12	20
31-60	17	29
61-90	7	12
91+	2	3
Total	**59**	**100**

In over half of the noncompliance incidents, corrective or final action was achieved in 30 days or fewer. Only 15 percent of the incidents required more than 60 days. EPA is currently drafting guidelines that will provide criteria against which timeliness of enforcement actions can be measured; as yet, however, no such criteria exist.

Unique Enforcement Situations Delayed Final Disposition

Nine of the noncompliance incidents (15 percent) required over 60 days to resolve. Two incidents required over 90 days for final disposition and seven others required between 61 and 90 days. In some instances, delays were caused by unique situations that prolonged the time taken to obtain corrective or final action. Examples of some of these incidents follow.

- In Louisiana, a $1,000 fine was imposed because monitoring equipment was inoperable for more than 4 hours. Final action required 63 days and time continued to run until the fine was paid, even though equipment was made operable within 2 weeks after the incident was discovered.

- In Illinois, a well operator determined that a noncompliance incident could not be corrected economically. A decision was made to plug and abandon the well. Time for corrective or final action continued to run for 154 days, until the well was plugged and abandoned.
- In Oklahoma, a noncompliance incident involving a question of excessive injection pressure continued to run through most of fiscal years 1985 and 1986, until the question was resolved. It was finally settled in an administrative hearing; the well operator submitted geological evidence showing that the injection pressure was in compliance with state regulations.

Fines Are an Enforcement Tool

EPA UIC regulations encourage but do not require that primacy states have procedures for the administrative assessment of penalties. Three of the states in our review—Louisiana in 1981, Texas in 1985, and Oklahoma in 1985—have granted this authority to the state agency operating the UIC programs. During the period of our review, only Louisiana had assessed penalties on hazardous waste wells for noncompliance incidents. On two occasions fines of $1,000 and $2,000, respectively, were imposed because operators allowed monitoring equipment to be out of working order for more than 4 hours; on one occasion a $10,000 fine was imposed when a well failed a pressure test conducted during a periodic inspection.

EPA Regions Are Overseeing State Enforcement Programs

QNCRs were being received by EPA regional offices from each state, and EPA regional personnel were monitoring the reported noncompliance incidents and accumulating data on types of incidents, enforcement actions taken, and time required to bring wells into compliance. Feedback on state program operations is provided to state program officials by telephone, written correspondence, and through mid-year and year-end program evaluations.

EPA regions are required to conduct an evaluation of each primacy state's UIC program at least annually. These evaluations include compliance and enforcement monitoring and are conducted both at mid-year and year-end by EPA. EPA's evaluations of the four states we reviewed include comments on compliance monitoring and enforcement, as well as other segments of the UIC program. Examples of comments included in the reports concerning compliance monitoring and enforcement follow.

- EPA Region V's fiscal year 1985 year-end evaluation report noted that Illinois lacked sufficiently trained personnel for field inspections. At

mid-year 1986, EPA found that a UIC field inspector had been added and efforts were being made to add another. The report also noted that Illinois had made significant progress in administering the UIC program.

- EPA Region VI's 1986 mid-year evaluation report commended Texas for its overall performance in administering the UIC program, but recommended that QNCRs provide additional information pertaining to the nature of the noted noncompliance and subsequent actions to return wells to compliance. The report also encouraged Texas to pursue more stringent enforcement actions, such as administrative penalties and/or referral for legal action.
- EPA Region VI's 1986 year-end evaluation report emphasized that Louisiana has an aggressive enforcement program, under which UIC regulations are enforced through actions ranging from informal notices to fines of up to $10,000. The report also noted that a review of inspection reports was made and that files show that inspections are timely and appropriate actions are taken for noncompliance incidents.
- EPA Region VI's 1986 year-end evaluation report credited Oklahoma with doing an adequate job in administering its UIC program. The report recommended that Oklahoma develop written enforcement procedures for follow-up actions on all noncompliance incidents, and develop tracking procedures for compliance monitoring.

Program Monitoring by EPA Not Fully Implemented

EPA Region V bears direct responsibility for the UIC programs in Michigan and Indiana. This includes assuring that timely MITs are conducted, that operator reports are received and reviewed, and that periodic inspections are scheduled and performed. While it is meeting program requirements in the area of mechanical integrity testing and while operator reports were being received and reviewed, it has not been conducting the required periodic inspections in these states. In addition, while regulations and program guidelines require an EPA headquarters oversight structure to assure that these three program elements are being effectively carried out by regional offices, no such structure is in place to ensure that inspections are performed.

EPA Region V assumed responsibility for implementing the UIC program in Michigan and Indiana on June 25, 1984. Michigan has 13 hazardous waste injection wells; Indiana has 8. These states were not given primacy to operate their own programs because both EPA and state officials agreed that these states' UIC programs were not sufficiently structured or financed to meet federal UIC requirements. Both states hope to obtain primacy over UIC programs at a future date.

The EPA Region V program for Michigan and Indiana calls for MITs to be conducted annually. Periodic inspections are required quarterly. Two inspectors are assigned to Michigan and four to Indiana. The inspectors are responsible for witnessing MITs as well as conducting periodic inspections on hazardous waste wells and all other classes of injection wells in these states.

EPA Meets Some Requirements in Michigan and Indiana

Our review showed that EPA was generally meeting program requirements for MITs and operator reports in Michigan and Indiana. UIC regulations require that hazardous waste wells in EPA-administered states have 1 year instead of 5 (primacy state requirements) to comply with permit conditions. All wells but one in the two states had successfully passed MITs during the required time frames. One Michigan well was temporarily shut down because of an MIT failure, and will not be permitted to reopen until repairs are made and it has passed an MIT.

Operator reports on the Michigan and Indiana wells were being received and reviewed. No deficiencies were recorded as a result of EPA's reviews on Indiana wells; however, seven incidents of noncompliance with a permit requirement, for not keeping annulus pressure sufficiently greater than injection pressure, were recorded by EPA on Michigan wells. The noncompliance incidents were considered minor since the variations were small. Corrective action was achieved by telephone calls to the operators; no other enforcement action was needed.

Program for Periodic Inspections Not Fully Implemented

As of April 1987, EPA Region V had not implemented a program for periodic inspections in Michigan and Indiana. Neither a written inspection strategy nor schedules showing when and where inspections were needed were found. While the Region V program calls for periodic inspections to be conducted quarterly, there were no records of inspections being performed during the 2-year period we reviewed, and no cases of noncompliance were identified on the basis of inspections.

According to Region V UIC program officials, inspectors made visits to all of the wells to witness MITs and help operators with permitting problems. Some of the activities performed during these visits could have overlapped into the periodic inspection area; however, no formal periodic inspection reports had been written. The officials said that the inspections were not conducted because permitting all the wells in these states has been a higher priority. EPA headquarters officials further explained that their reporting system enables them to count only one

inspection for multiple-purpose investigations occurring on the same day at the same well.

Subsequent to our review of this program, we have been informed by Region V officials that efforts are being made to implement a structured periodic inspection program for hazardous waste injection wells in Michigan and Indiana. We have been provided with inspection reports that reflect that periodic inspections have begun to be made, and that noncompliance incidents are being identified and recorded.

Noncompliance Reports Not Submitted

Required QNCR reports were not being prepared and submitted to EPA headquarters by Region V at the time of our review. Beginning with the first quarter of fiscal year 1987, Region V began submitting QNCRS.

EPA Headquarters Not Providing Sufficient Oversight to Regions

While EPA regions are overseeing primacy state activities, when EPA regions (such as Region V) function as the direct permitting authority, there is no corresponding check by EPA headquarters. The EPA headquarters Office of Water did conduct a fiscal year 1986 mid-year review of Region V's performance in water program management, which included limited comments on the UIC program. However, the mid-year review did not identify the fact that Region V did not conduct periodic inspections or submit QNCRS, nor did it contain findings and recommendations on the hazardous waste injection well program. EPA headquarters has not performed an in-depth evaluation such as those made of primacy state programs by EPA regions.

According to EPA officials, however, beginning in fiscal year 1987 they extended the mid-year review from 1 and 1/2 days to 3 days and initiated an additional program oversight activity—peer reviews. During the peer review process staff from EPA's Office of Drinking Water and regional offices review and comment on the operations of UIC programs for which EPA is responsible. During fiscal year 1987, EPA officials reported conducting peer reviews in four regions.

Conclusions

In the primacy states we reviewed, an oversight structure has been established and implemented; noncompliance incidents have been identified and corrected. In reviewed states for which EPA bears direct responsibility, however, EPA headquarters had not performed oversight evaluations of EPA regions' UIC program that ensured that inspections were performed and QNCRS were submitted. As a result, only parts of the

system were working. Required periodic inspections were not performed, and QNCRS were not prepared and submitted to EPA headquarters during fiscal years 1985 and 1986 for the 21 wells in 2 states under EPA Region V's oversight jurisdiction. Until the periodic inspections are performed and the QNCRS submitted, the possibility of violations not being identified and therefore not being corrected continues to exist, as was possible during the past 2 years.

Recommendations to the Administrator, EPA

To ensure that the regulatory oversight functions built into the UIC program for hazardous waste injection wells are in fact being performed in states for which EPA bears direct responsibility, we recommend that the Administrator, EPA, strengthen the program's oversight functions by

- requiring that EPA headquarters annually evaluate each regional office operating a UIC program, to ensure, at a minimum, that the program's regulatory oversight functions (MITS, periodic inspections, and operator reports) are being performed; and
- reemphasizing to EPA regions with direct UIC program responsibility that they are to perform and document periodic inspections and report noncompliance incidents to EPA headquarters, as required in UIC regulations.

UIC Program Changes Expected to Further Safeguard Drinking Water

Under federal law, the injection of hazardous waste will be banned effective August 8, 1988, unless well operators or owners can demonstrate that the waste being disposed will not leave the injection zone as long as it remains hazardous. To implement this law, EPA plans to issue regulations stipulating how injection well operators/owners can demonstrate no migration. These regulations will also require well operators to comply with stricter permitting and operating requirements designed to assure that hazardous wastes reach the injection zone and do not migrate.

These program changes are intended to provide additional safeguards to prevent injected hazardous waste from contaminating underground sources of drinking water. Information about what happens to injected waste is sufficient, EPA believes, for well operators/owners to demonstrate that the waste will remain contained. Some environmental groups, however, believe that the proposed demonstrations will not assure no migration. EPA expects most hazardous waste injection wells to be able to meet the stricter requirements and continue operating.

Curtailing Hazardous Waste Disposal in Injection Wells

The Hazardous and Solid Waste Amendments of 1984[1] prohibit the land disposal of untreated hazardous waste beyond specified dates unless the EPA Administrator determines that the prohibition is not required to protect human health and the environment while the waste remains hazardous. Furthermore, a method of land disposal is not considered protective unless it has been demonstrated with reasonable certainty that the hazardous constituents will not migrate from the disposal unit or injection zone for as long as the waste remains hazardous. Hazardous waste treated according to standards set by EPA, however, is not subject to these prohibitions and may be land-disposed.

The 1984 amendments established deadlines by which EPA must promulgate regulations on treatment standards or determine, on the basis of case-specific petitions, that the hazardous waste will remain in the disposal unit or injection zone. Table 4.1 lists the timetable for prohibiting disposal through injection wells and other land-disposal methods.[2] The first restrictions for hazardous wastes take effect August 8, 1988, for injection well disposal and took effect November 8, 1986, for other land-disposal methods. The law gives EPA until August 8, 1988, to review the

[1] To the Resource Conservation and Recovery Act of 1976

[2] Other land-disposal methods include placement of waste in a landfill, surface impoundment, waste pile, land treatment facility, salt dome or salt bed formation, or underground mine or cave.

injection disposal method. The issue concerning migration from injection wells differs substantially from migration from other land-disposal sites. For example, waste disposed of in injection wells must be kept from migrating through hundreds of feet of rock through faults, fractures, or abandoned wells, while waste disposed of on the surface must not migrate beyond man-made liners or receptacles.

Table 4.1: Effective Dates for Land-Disposal Restrictions

Hazardous waste category	Injection wells	All other land-disposal methods
Solvents	Aug 8, 1988[a]	Nov. 8, 1986[b]
Dioxins	Aug. 8, 1988	Nov. 8, 1986[c]
"California list"[d]	Aug 8, 1988	July 8, 1987
At least one-third of all other listed wastes	Aug 8, 1988	Aug 8, 1988
At least two-thirds of all other listed wastes	June 8, 1989	June 8, 1989
All other listed and identified wastes	May 8, 1990	May 8, 1990

[a]EPA proposes extending the effective date for certain solvents to August 8, 1990

[b]EPA extended the effective date for certain solvents to November 8, 1988

[c]EPA extended the effective date to November 8 1988

[d]Includes heavy metals at specific concentrations, acids polychlorinated biphenyls (PCBs), and halogenated organic compounds

EPA has extended the effective date for prohibiting the land disposal of certain solvents to November 8, 1988, because of limited treatment capacity. For the same reason, EPA is proposing, in draft injection well regulations, a 2-year extension for the same solvents. Likewise, EPA has extended by 2 years the effective date of restrictions for the land disposal of dioxins on the basis of insufficient treatment capacity. EPA does not, however, propose extending the effective date for underground injection of these wastes, since available data show that no wastes containing dioxin are currently being injected.

After these deadlines pass, two ways will remain in which hazardous waste can continue to be disposed of on land—the waste can be treated prior to disposal so that it is no longer hazardous, or the operator/owner can demonstrate that the hazardous waste will not migrate from the disposal unit or injection zone. Injected waste will be subject to the same treatment standards as waste disposed of by other land methods. However, according to an EPA official, demonstrations of no migration, rather than treatment before injection, will be the predominant means by which injection well operators will be able to continue to dispose of hazardous waste.

Proposed Regulations to Implement the 1984 Amendments

Proposed regulations to implement the 1984 amendments for injection well disposal will require well operators/owners to (1) demonstrate, in a petition to their permitting authority, that the hazardous waste will not migrate from the injection zone and (2) obtain revised permits that incorporate new permitting and operating requirements that are included in the proposed regulations. The purpose of the stricter technical requirements, which will have to be incorporated in revised permits for all existing hazardous waste wells, is to assure that the waste reaches the injection zone, from which it may not migrate.

Early drafts of the proposed regulations were written by a negotiating committee whose members represented EPA, state regulatory agencies, environmental groups, and industries that use injection wells. The negotiating committee met from September 1986 through April 1987. Because a consensus on the proposed regulations was not reached by the committee, EPA drafted the regulations using information and views provided by committee members. Negotiations broke down when some representatives of environmental groups withdrew from the committee primarily because of differing opinions on whether no migration would be demonstrated under the proposed regulations. EPA officials expected to issue the proposed regulations in August 1987 for public comment. They plan to issue final regulations by February 1988.

Demonstrating No Migration

Under the proposed regulations, the no-migration standard can be met in one of two ways: by demonstrating that the waste transforms into nonhazardous material, or by demonstrating that the waste will not migrate out of the injection zone. According to EPA, sufficient information on waste transformation and fluid movement is available with which to make such demonstrations

Well Operators Will Have to Successfully Petition to Continue Operating

One way that well operators can continue to dispose of "prohibited" hazardous waste is by demonstrating that the waste will no longer be hazardous when it leaves the injection zone. For some hazardous waste, this could be accomplished by showing that the waste has lost its hazardous characteristics. For example, acid waste may be neutralized by the formation with which it comes in contact. For other waste, this could be accomplished by demonstrating that the constituents would be transformed into nonhazardous by-products or attenuated to nonhazardous levels. The other way that well operators can continue to dispose of hazardous waste is by demonstrating that the site conditions are such that hazardous fluids will remain in the injection zone for 10,000 years.

To meet either standard, well owners or operators are required by the draft regulations to submit petitions to their permitting authorities, who will review them prior to submitting them to EPA. EPA will approve or disapprove the petitions. All petitions must

- identify the specific waste or wastes and the specific injection wells for which the demonstration will be made and
- describe fully the chemical and physical characteristics of the wastes to be injected.

In addition, petitions that are demonstrating transformations into non-hazardous material must include sufficient information about the specific waste to be injected to ensure reasonably reliable predictions about the waste transformation. The petitioner must also provide the information necessary to support the petition, such as a description of the chemical processes or other means that will lead to waste transformation and the results of laboratory experiments verifying the waste transformation.

Petitions seeking to demonstrate no migration of the injected waste must provide site-specific information such as the hydrogeological characteristics of the injection zone, the movement of natural fluids in the injection zone, and the thickness and permeability of the confining zone.

Finally, petitions that are making either demonstration must show that (1) the overlying confining zone is at least four times as thick as the injection zone and (2) the injection zone is separated from the closest drinking water by a distance at least ten times greater than the thickness of the injection zone.

EPA Considers Research Sufficient to Demonstrate No Migration

According to EPA, sufficient research has been conducted on the transformation of wastes and underground fluid movement to make such demonstrations possible. For example, a comprehensive literature survey on the transformation of hazardous waste conducted by the National Institute for Petroleum and Energy Research (NIPER) identified and evaluated 79 studies, discussing what is known about nonorganic and organic hazardous materials and interactions between injected waste and the injection zone at specific deep-well sites. This report concluded that some information is available on most potential chemical

and biological transformations of hazardous waste.[3] The study also found that mathematical models successfully predict certain chemical processes affecting nonorganic wastes.

Research conducted by EPA and others on the transformation of hazardous waste into nonhazardous material also shows evidence of

- chemical transformation of some hazardous waste by reaction with water;[4]
- bacterial degradation of many hazardous organic compounds;[5]
- reduced concentrations of hazardous constituents caused by reactions within the waste stream or by reactions with the injection formation;[6] and
- injected metals being immobilized in the injection zone by reactions with the injection formation.[7]

According to EPA, fluid flow in deep formations is also fairly well understood, and can be estimated using existing models. In reviewing literature on underground injection, we found that many models and analytical formulas have been developed to calculate subsurface fluid movement. For example, a report by Prickett, Warner, and Runnells provides over 50 references to studies on fluid movement.[8] They describe simple analytical equations that estimate pressure build-up in the injection zone and the direction in which the injected fluid is migrating, as well as complex numerical models that simulate fluid movement under varying subsurface conditions.

Models have been developed by academic institutions, the petroleum industry, and government agencies that estimate fluid flow. For example, researchers at the University of Oklahoma developed a computer

[3] "Injection of Hazardous Wastes Into Deep Wells" by A. Strycker and A.G. Collins, National Institute for Petroleum and Energy Research, Bartlesville, Okla., December 1986.

[4] "Measurement of Hydrolysis Rate Constants for Evaluation of Hazardous Waste Land Disposal" by J.J. Ellington, et al., EPA, Office of Research and Development, Athens, Ga. (no date).

[5] "Anaerobic Transformation Processes: A Review of the Microbiological Literature" by J.E. Rodgers, EPA, Office of Research and Development, Athens, Ga., Sept. 8, 1986.

[6] "Chemical Fate of Injected Wastes" by N.C. Scrivner, et al., in Proceedings of the International Symposium on Subsurface Injection of Liquid Wastes, New Orleans, La., 1986, pp. 560-609.

[7] Strycker and Collins, p. 21.

[8] "Application of Flow, Mass Transport, and Chemical Reaction Modeling to Subsurface Liquid Injection" by T.A. Prickett, et al., in Proceedings of the International Symposium on Subsurface Injection of Liquid Wastes, New Orleans, La., 1986, pp. 447-463.

program that estimates the location of an advancing waste front over time as fluid is injected at constant or variable pressure.[9] The program can be used for wells injecting into formations with variable thicknesses, permeability, or porosity. It also can be used to analyze the disposal of wastes from multiple wells simultaneously or alternately.

Researchers at E.I. duPont de Nemours and Co. have developed a variety of mathematical models to analyze the flow and containment of waste within an injection formation.[10] Their models estimate the maximum upward movement of injected fluid into the confining zone, the outer boundary of the injected waste, and the area over which pressure increases in the injection zone could cause fluid to migrate up an unplugged abandoned hole. They applied these models to an injection well site near Victoria, Texas, where DuPont has been injecting waste since 1953 and has ten active injection wells. The results of one model, when applied to the Victoria site, predict that, if injection were stopped today, waste would never penetrate more than 1 percent of the confining layer.

Another example of a model that calculates the movement of injected fluids is the Survey Waste Injection Program, developed for the U.S. Geological Survey.[11] This model and others that are derived from it estimate fluid movement over time by considering varying properties of the injection formation and some chemical and physical transformations of the waste.

Environmental Groups Refute Demonstrations of No Migration

Some representatives of environmental groups withdrew from the negotiated rulemaking because, among other reasons, they believed the draft regulations did not assure no migration of injected waste. These individuals believed that demonstrations of no migration could be made at particular sites on the basis of chemical transformation of hazardous wastes into nonhazardous compounds. They also believed that flow and transport models can be appropriate predictive tools. They asserted, however, that these models did not provide a reasonable degree of certainty that waste would not migrate on the basis of an example presented by EPA officials at the last negotiated rulemaking session.

[9]"Analysis of the Migration Pattern of Injected Wastes" by E.C. Donaldson and A.A. Rezaei in Proceedings of the International Symposium on Subsurface Injection of Liquid Wastes, New Orleans, La., 1986, pp. 464-484

[10]"Flow and Containment of Injected Wastes" by C. Miller, et al., in Proceedings of the International Symposium on Subsurface Injection of Liquid Wastes, New Orleans, La., 1986, pp. 520-559.

[11]Prickett, et al., pp. 452-453

EPA's example showed waste moving 100-200 feet vertically at the wellbore above the injection site over 10,000 years. Representatives of some environmental groups felt that this much movement of waste was unacceptable. According to EPA officials, their example modeled fluid movement at a hypothetical injection well using a worst-case scenario with extremely conservative assumptions that excluded many factors normally impeding subsurface fluid movement. Furthermore, according to EPA officials, more realistic assumptions show that in many cases, injected fluid would migrate only 10 to 20 feet upward.

Stricter Technical Requirements

In addition to demonstrating that the waste will not migrate from the injection zone as long as it remains hazardous, well operators or owners will have to comply with new technical requirements. The technical requirements are part of the proposed regulations that define the no-migration standard. These requirements will have to be incorporated into revised permits and will be enforced as permit requirements.

The proposed regulations cover the same areas—such as permitting, operating, and reporting requirements—as do the current regulations. However, they propose additional, more stringent requirements in many areas in order to further safeguard underground drinking water. EPA is proposing new regulations because recent information showed areas where additional safeguards might be desirable, and because of additional groundwater-monitoring requirements mandated by the Safe Drinking Water Act Amendments of 1986. Key provisions of the proposed regulations include

- more specific well-siting requirements;
- expanded "area of review" around injection wells for identifying abandoned wells near the injection site and added requirements for corrective action to plug abandoned wells;
- additional operating procedures, such as automatic well shutoff or alarms;
- new requirements for testing, monitoring, and reporting, including a waste-analysis plan, additional mechanical integrity tests, and more specific monitoring requirements; and
- new requirements for well closure and post-closure care.

Well Siting

The proposed regulations retain the current requirements for siting wells beneath underground sources of drinking water and for information to be considered in evaluating permit applications. They also add

some qualitative factors—such as assuring that the injection zone is sufficiently permeable and large to prevent migration of fluids into underground drinking water.

The proposed regulations add three siting requirements. The owner or operator must show that one of the following conditions exists:

- There is at least one additional layer of permeable and confining formations between the confining zone and the underground source of drinking water.
- The natural flow of groundwater is such that any fluid leaking out of the injection zone would flow away from any underground source of drinking water.
- There is no underground source of drinking water present.

Area of Review

The area of review is the area within which the owner or operator must identify all wells penetrating the injection and confining zones and determine whether they have been properly completed or plugged. Unplugged or improperly plugged bore holes provide pathways for injected fluid to escape the confining zone and potentially endanger nearby sources of drinking water.

In the current regulations, the area of review is defined either by a fixed radius of one-quarter mile around the proposed well or a radius calculated using a prescribed formula. The proposed regulations require that the area of review be either

- a 2-1/2-mile radius around the well bore or
- a radius around the well calculated using a new formula, whichever is greater.

This will bring the federal standard in line with several states' practices. Among the states in our review, Texas and Illinois have a 2-1/2-mile area of review, and Louisiana's area of review is 2 miles.

Under the proposed regulations, the owner or operator will be required to submit to the permitting authority a plan for identifying all wells within the area of review and determining whether such wells are adequately plugged. Under current regulations, the owner or operator must submit a plan that only covers steps taken to correct improperly completed or abandoned wells that enter the area of review.

Operating Requirements

The proposed regulations add several operating requirements:

- Annulus pressure having to exceed injection pressure to ensure that if the injection tubing leaked, annulus fluid would always move into the tubing and waste would never move into the annulus.
- Controls on wells injecting waste that could generate gasses, to assure that operational problems do not occur.
- Automatic alarms and shutoff devices, designed to be activated when pressures and flow rates exceed levels specified in the permit.
- Notification of the permitting authority within 24 hours of an automatic alarm or shutdown being triggered.

Testing and Monitoring

The proposed regulations add requirements for a waste-analysis plan and additional tests on the well during construction, specify requirements for monitoring compatibility between the well construction material and injected fluid, revise mechanical integrity testing, and establish more specific requirements for monitoring waste movement. The monitoring requirements were added in response to the 1986 amendments to the Safe Drinking Water Act, which require EPA to identify and evaluate methods to monitor the possible migration of injected waste in the direction of underground drinking water. The monitoring requirements will apply to all class I wells, not just those used for hazardous waste disposal.

Current regulations require owners or operators to analyze the injected fluid "with sufficient frequency to yield representative data of their characteristics." The proposed regulations require the owner or operator to develop a written plan describing how the waste will be analyzed and the sampling method that will be used to obtain a representative sample.

The proposed regulations require additional tests and procedures to be run during drilling and construction of new hazardous waste wells to determine or verify the depth, thickness, porosity, permeability, rock type, and salinity of formation fluids. These data will assure conformance with siting requirements and establish accurate baseline data against which future measurements can be compared. The proposed regulations will also allow the permitting authority to require monitoring, when corrosive wastes are injected or when the permitting authority deems appropriate, to determine the effect of corrosion on the well material.

Currently, EPA requires that mechanical integrity tests be run at least once every 5 years. The proposed regulations require this test, which consists of pressure tests, radioactive tracer surveys, and other tests that may be required, to be conducted annually. The radioactive tracer surveys are used to locate leaks in the cement at the bottom of the well hole. In addition, the proposed regulations require using a tool to evaluate the casing prior to operating the well, and every 5 years afterwards. This tool measures the thickness of the casing, which indicates when a leak is present and shows weaknesses that may be developing in the casing.

The 1986 amendments to the Safe Drinking Water Act require EPA to identify and list methods for monitoring waste movement for class I wells. In response to this law, the proposed regulations require the owner or operator to develop a monitoring program that includes, at a minimum, annually monitoring the pressure build-up in the injection zone when the well is not injecting. In certain circumstances, the well operator or owner may also be required to install a monitoring well in the formation immediately above the confining zone to monitor continuously for pressure changes.

When a monitoring well is installed, the owner or operator will be required to monitor the groundwater quality. The monitoring program may also require additional monitoring, including

- the use of indirect, geophysical techniques to determine the position of the waste front;
- periodic monitoring of groundwater quality in the first aquifer overlying the injection zone; or
- periodic monitoring of groundwater quality in the lowermost underground source of drinking water.

Quarterly Reports

The proposed regulations add several new reporting requirements to the quarterly reports that operators submit to the permitting authority. The owner or operator will be required to report on changes in the relationship between injection pressure and flow rate or volume that go beyond a range specified in the permit, a description of any event that triggers an automatic alarm and the response taken, the total volume of fluid injected, and the volume of annular fluid lost.

Well Closure and Post-Closure Care

The proposed regulations add three requirements that well operators must meet prior to closing the well:

- observing and recording the decline in pressure in the injection zone for a time specified by the permitting authority,
- demonstrating the well's mechanical integrity prior to plugging the well, and
- flushing the well with a buffer fluid prior to plugging it.

The proposed regulations also add post-closure care requirements to injection wells, which require well operators to monitor the well until the pressure in the injection zone reaches background level.

Expected Impact of Proposed UIC Program Changes

The proposed regulations are expected to have little effect on the number of wells currently injecting hazardous waste, according to EPA officials. Enough ways exist to demonstrate no migration, so most wells currently operating can probably continue to do so. To meet stricter siting requirements, however, some wells may have to be drilled deeper or they will have to stop operating.

According to an EPA official, some commercial wells may have to stop operating because they do not meet the no migration of hazardous constituents requirement of the 1984 amendments to RCRA. Another EPA official acknowledges, however, that the diverse waste streams would not preclude them from making the demonstration on the basis of fluid movement. Since commercial wells comprise a relatively small number of wells—only 17 of the 181 active hazardous waste injection wells are commercial and account for only about 4 percent of the hazardous waste injected in wells—the new regulations are expected to have little effect on the number of wells disposing hazardous waste and the volume of waste disposed.

Not all wells meet the proposed minimum distance between the injection zone and the lowermost underground source of drinking water, according to an EPA official. Some wells may have to be drilled deeper to meet the requirement. Other wells may have to stop operating because the geological characteristics of the site prevent the well from being drilled deeper. For example, certain areas in Florida and the Midwest have thin confining zones and relatively shallow injection zones. In such areas, the formation used as an injection zone may be too close to the lowermost underground source of drinking water and deeper formations are not suitable injection sites. EPA has no information on the number of wells

that may be drilled too shallow for the proposed regulations. However, an EPA official estimated that less than 5 percent of the wells would have to stop operating because they could not be drilled deeper.

Conclusions

The proposed regulations should provide additional safeguards to prevent the contamination of underground sources of drinking water. Owners of new and existing underground hazardous waste injection wells will be required to demonstrate no migration of hazardous waste and certify compliance with stricter permitting and operating regulations. With few exceptions, EPA expects that wells will pass a demonstration of no migration, meet the more stringent controls, and continue to operate.

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Glossary

Annulus	the space between the injection tubing and outer pipe of an injection well.
Aquifer	a layer of very porous rock that is capable of holding and transmitting water.
Black Water	naturally occurring water in underground formations that contains iron sulfides.
Blowout	a sudden, violent expulsion of fluid, gas, and mud from a well, followed by an uncontrolled flow from the well.
Casing	a pipe used to seal off fluids from a well's bore hole or to keep the hole from caving in. There may be several strings of casing, one inside the other, in a single well.
Confining Zone	the formation or formations above the injection zone that are capable of limiting fluid movement.
Injection Tubing	the innermost pipe of an injection well, through which waste is injected.
Injection Zone	the underground formation into which waste is deposited.
Mechanical Integrity Tests	various tests used to determine whether a well has sound operating components and to check for leaks.
Off-Site Wells	commercial underground injection wells that are used to dispose of waste that has been generated by others at other locations.
Packer	a device used on casing or tubing to prevent fluid from passing.

Permit-By-Rule	a provision of Subtitle C of the Resource Conservation and Recovery Act (RCRA) whereby a facility is deemed to have a RCRA permit if it is permitted under the Safe Drinking Water Act, the Clean Water Act, or the Marine Protection, Research, and Sanctuaries Act and also meets a few additional Subtitle C requirements.
Primacy State	a state that has been delegated program responsibility for the UIC program by EPA.

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